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ABSTRACT

The material presented in this booklet is concerned with the impact of physical activity practiced by the general public, irrespective of age and sex, of various North American and European countries. Major emphasis is on the individual's physical health and susceptibility to disease. Chapter one discusses diseases which occur most frequently in populations, costs of health expenditures, and improvement of health standards. Chapter two presents demographic studies attempting to correlate the amount of physical activity with coronary disease and details ways in which the heart can be protected. Chapter three deals with physical activity and neurophysiological equilibrium; chapter four takes up physical activity and the capacity for work; and chapters five and six describe physiological characteristics of aging and physical activities necessary for optimal enjoyment of life. (Related document: ED 007 485.) (JB)

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PHYSICAL ACTIVITY AND THE PREVENTION OF DISEASE

Facts and figures

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The facts and figures set out in the following paper have been selected from the most significant in a wealth of medical literature. Some aspects of the influence of physical activity on health have had to be omitted altogether, while others are only touched on. The aim was to indicate the universal benefits to be derived from sporting activities, and to justify a general conviction by statistical and scientific data. No attempt has been made to discuss the way in which such a conviction can be transposed into practical terms.

I should like to thank Professor P.O. Åstrand, Professor G.A. Canaperia and Professor W. Hollmann for the documentary material and information they have been so kind as to send me.

INTRODUCTION

The increasing incidence of certain diseases and the continuous rise in the costs they entail in terms of both medical care and productivity are making it necessary for us to revise our medical and social approach to such complaints, which are essentially connected with the industrial and urban environment, and the increasing age of the population. They take the form in particular of psychosomatic or mental disorders, degenerative and cardiovascular diseases. This pathology of civilisation needs to be considered from the still virtually neglected standpoint of prevention. Through joint studies by doctors, town-planners and economists, it should be possible to work out a new conception of healthy living, one that is physical, psychological and occupational. Among the measures necessary for the preservation of health, physical exercise and sport seem to play a leading part in adjusting man to his new living conditions.

The material presented here is concerned with the impact of physical activity practised by the whole population, irrespective of age or sex. That impact is not seen from the angle of competitive sport, where motivations whether overt or not, are quite different.

In the years ahead, increasing participation in sporting activities will become part of a way of life whose social, demographic and health features are summarised in what follows.

CHAPTER I

FORESEEABLE TRENDS IN LIVING HABITS MORBIDITY AND HEALTH EXPENDITURE

Living habits in 1985

Population expansion is likely to continue, with an annual rate of increase of 0.6 — 0.9 % in Europe. A particular feature will be an increase in the proportion of persons over the age of 65 : by 1985 the proportion will have attained 14-15 % in France, for example, and even more in most of the at present "younger" countries of Europe. The economic burden constituted by this large number of non working old people will be the greater, the more deficient their physical condition is and the more firmly irreversible, chronic degenerative diseases have been allowed to become established in them [1, 2*].

Urbanisation will go on increasing, and 70-80 % of the population will be living in towns. Nervous and physical strain, the price to be paid for urban concentration, is not likely to lessen : traffic problems, the hustle and bustle of daily life, noise, air and water pollution, the remoteness of the countryside and open spaces, and psychological isolation.

As far as working conditions are concerned, monotony, "compartmentalisation" and the transformation of people into robots will still be common features, partly offset by a reduction in working hours. Occupations involving a high degree of physical activity will tend to disappear.

On the other hand, there will be a significant increase in the amount of time available for leisure, owing to shorter working hours, the general institution of the continuous working day, longer holidays and a lower retiring age. With a considerable increase in living standards, much of people's time and income will be absorbed by the leisure industry. It is reckoned that by 1985 11.4 % of the average family's budget will be spent on leisure, compared with 8 % in 1960, whilst expenditure on most other items will have fallen [3]. The situation should therefore be favourable for guiding this increased leisure towards sporting activities.

The diseases lying in wait for us

The history of diseases shows that as soon as one disease has been conquered another takes its place. Ultimately, no doubt, infectious diseases will be permanently reduced to the status of benign episodes, whilst metabolic and degenerative diseases, particularly arteriosclerosis, will assume proportions which are already being described as epidemic. If death often reflects the life which preceded it, the World Health Organisation's mortality statistics speak for themselves in this regard :

Among *the principal causes of death* in the industrialised countries, cardiovascular diseases and cerebrovascular accidents ("apoplexy") together account for 45 % of deaths. Next comes cancer, at all ages. An appalling proportion of deaths amongst adolescents, and still a high one amongst young adults, is caused by accidents whether on the road or at work. For other causes of death, however, percentages are much lower. These include, with some variations in incidence from one country to another, tuberculosis, suicide, cirrhosis, diabetes, bronchial ailments and nephritis [4, 5, 6].

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* See bibliography, page 37.

Table I

Principal causes of death recorded in 23 industrialised countries

(WHO, 1965)

Cause of death	5-14 years	15-44 years	45-64 years	> 64 years	% all ages
Cardiovascular diseases	cong. malf. 7 %	12 %	30 %	36 %	32.5 %
Cancer	15 %	19 %	30 %	16 %	18.6 %
Apoplexy		3 %	8.6 %	16 %	13 %
Accidents	43 %	27 %	4.5 %	2.5 %	5 %
Influenza and pulmonary infections	4 %	1.8 %	1.8 %	3.6 %	3.3 %

These percentages have changed considerably in the last 20 years. With the control of infectious diseases, particularly tuberculosis, and the resultant increase in life expectancy, it is cancer and cardiovascular diseases which now develop most frequently as people grow older. As therapeutic medicine progresses, the differences between the percentages showing an increase and the others are likely to become even greater. Should a cure have been found for cancer by 1985, it is not inconceivable that by then death will result only from accidents or cardiovascular degenerative lesions — a kind of death from normal ageing, a "biological" death of the human species.

But at what age will that death occur ? Is the time coming when many octogenarians, ablebodied or not, will be kept alive ?

There has been a steady increase in *expectation of life :* 40 years in 1870, 68-77 years in 1970 according to sex and country. But this is the expectation of life at birth, and the progress is mainly due to the virtual eradiction of infant mortality. In fact, the sexagenarian of today can hope to live another 18 years, compared with 12 years 150 years ago. For there to be further progress, there would have to be a decline in mortality not amongst young children but amongst old people.

In absolute terms, the total disappearance of mortality from infectious diseases and cancer would increase the average life-span by 6.5 years. But the years gained would come late in life, which is when the effect of cardiovascular disease is most felt. The actual reprieve would therefore be short on the average ; indeed for 10 years the expectation of life has been tending to level off in the very countries where it had risen most, viz., Norway, Sweden and the Netherlands [7].

In addition the excess mortality of the male sex is increasing. In the Netherlands, men live 4 years less than women (1.5 before 1940) and in France 7 years. This difference is the consequence of war, occupational strain and hazards, accidents and nicotinism. Another factor is alcoholism, causing cirrhosis, cancer of the digestive system and accident-proneness.

This brief incursion into the demographic field gives, however, only a rough picture of disease trends. There are many diseases not included in mortality statistics whose personal and social impact is nevertheless such as to warrant consideration of their present and future incidence.

Morbidity statistics, the best barometer of health standards, are unfortunately less precise than mortality statistics. The following two tables may be considered by way of a sample [4].

Table II

Principal causes of disablement (France)

Causes of disablement	1950	1958	1965	1968 (Paris)
Psychoses	6.25 %	9.53 %	15.00 %	20.17 %
Arthritis and rheumatism	5.72 %	9.08 %	10.61 %	10.24 %
Tuberculosis	26.60 %	22.92 %	9.04 %	5.72 %
Cerebral vascular injuries	2.30 %	3.84 %	6.39 %	7.59 %
Arteriosclerotic and degenerative diseases of the heart	7.19 %	7.74 %	9.03 %	8.55 %
Tumours	3.44 %	3.88 %	4.28 %	5.51 %
Accidents	1.75 %	3.12 %	2.97 %	3.04 %

Table III

	Number of cases from each cause per 1,000 cases from all causes (FNOSS, France, 1964)	Monthly number of cases per 1,000 respondents (Denmark, 1951-54)	Patient consulting rate per 1,000 inhabitants (England and Wales)
Diseases of the respiratory system, Influenza, Nasopharyngitis	295	292	527
Diseases of the digestive system	173	155	224
Diseases of the circulatory system	72	107	135
Disease of the genito-urinary system	71	127	102
Accidents and poisonings	67	27	205
Diseases of the bones and joints	66	211	152
Diseases of the skin	64	48	311
Diseases of the nervous system and sense organs	57	19	139
Mental disorders	38	62	98
Infective diseases and pulmonary tuberculosis	33	11	110
Allergic and endocrine diseases	25	36	100
Diseases of the blood	9	8	28
Tumours	6	7	21
Other conditions	26	125	214
	1,000		

Thus, the most common diseases are not those shown on death certificates. But such diseases do account for most medical consultations, interruptions of work and expensive prescriptions. Although for some of them the question does not arise, for others it may be seriously wondered how far sport can reduce their prevalence or gravity.

Let us look again at the diseases which recur most often — if not in the same order of prevalence — in these morbidity, disablement and mortality statistics. These are also the diseases whose incidence is rising in both relative and absolute terms. What is their foreseeable evolution [8] ?

Neurodystonias are constantly increasing. They do not always result in psychiatric manifestations (neuroses, anxiety, asthenias), but their psychosomatic manifestations, in the form of dyspepsia for instance, largely account for the extent to which treatment of the digestive system is required. These numerous "functional diseases" place an excessive burden on practitioners and health budgets. They are the direct consequence of harmful environmental influences, of the evils of industrial and urban civilisation, and also of a certain upbringing which leads to their being endured rather than eradicated.

The diseases whose incidence shows the next highest rate of increase are *cardiovascular diseases*. This too, can be attributed to the ill effects of modern life which can give rise to minor functional manifestations in the heart just as much as to myocardial infarction, of which stress is a fundamental cause.

But this increase in prevalence, the combined effect of the disappearance of natural selection and the lengthening of man's life-span, does not affect old people alone. There is a disturbing increase in the occurrence of infarcts in young, fully active people. These conditions severely incapacitate those suffering from them ; they cannot be cured, at best only stabilised, and their number is not brought down by drugs.

Efforts must therefore be made to prevent them ; in this, physical exercise can play an important role. The same applies to chronic bronchitis, a cause of disablement which is sharply increasing, not least in Great Britain.

Virus infections, both seasonal and epidemic, of which influenza is the most common, will be held in check by increasingly effective vaccination and therapy. It may be wondered, however, whether the extent of their material consequences is not due to the circumstances in which they occur. Does man in 1970 have the necessary physical strength and mental resistance to overcome these benign diseases ? Would the influenza "psychosis" spread among a population in sound physiological condition, i.e. an athletic population ?

Similarly, shall we be physically able to reduce the effect on our health of the *noxious concomitants* of industrialisation and mechanisation, which are only beginning to be indentified — intoxication or drug-addiction, air pollution, water pollution, disablement through injury (much more common than death through injury) ?

In this brief review of health trends in our industrialised countries mention must also be made of the economic aspects and the continuous rise in health expenditure.

Health expenditure

In the last 15 years health expenditure in the more developed countries has been rising unpredictably. An international study on the cost of health (WHO, 1967) shows that the rate of increase is in general such that an additional 1 % or more of the gross national product (GNP) is spent on health services every 10 years. If present trends continue, some countries will be spending more than 10 % of their GNP on health services by the end of the century [9].

Table IV

Estimated expenditure on personal health care :
hospital services, physicians' services and prescribed drugs (excluding dental care) as % of GNP

Country	1953	1961	Average annual increase as % of GNP
Canada	2.50	3.85	0.17
United States	2.31	3.46	0.14
New Zealand	3.10	3.59	0.06
Australia	2.72	4.06	0.17
United Kingdom	2.58	2.98	0.05
France	2.18	3.28	0.14
Norway	2.25	2.71	0.06
Denmark	1.91	2.42	0.06
Netherlands	1.71	2.32	0.08

This increase in medical consumption is more rapid than the increase in any other form of consumption. In France, medical expenditure amounted to 9.9 % of a family budget in 1960 and by 1985 it is expected to amount to 15.2 % [3].

In the years ahead the same trends are likely to continue. In the United States, it is anticipated that health expenditure will increase by 140 % between 1965 and 1975, whereas the national income will rise by only 85 %.

Medical and pharmaceutical consumption is indeed a fact of civilisation. Curiously, its increase is parallel to that of the consumption of electricity. It is the result of technical progress, more and more diseases being effectively treated by means of more and more increasingly expensive laboratory tests, surgical treatment and radiotherapy. It is the result of the survival of fragile, handicapped people who, year by year, will be major consumers of medical care. It will increase further as the present under-consumption by the agricultural population and old people is reduced (making due allowance for different degrees of morbidity, old people consume less nowadays than other adults). The number of consumers is expected to increase as urbanisation spreads and cultural standards rise, and it is forecast that the average annual number of medical consultations will rise in Belgium, for instance, from 6.76 in 1963 to 10.46 in 1980. In rich countries, lastly, this consumption depends little on whether or not there is social insurance coverage of medical expenditure, which is a matter of priority in the estimation of the public. In this day and age, good health is regarded as a right, and the provision of virtually free medical care as all but a necessity.

The share of hospital treatment in such expenditure (40 %) will go on increasing. This share represents the "pacemaker" expenditure of medicine, the "high-technology" expenditure (transplants, treatment of chronic uremia, for example) which still affects only a few of those who ought to benefit from it : as much as 50 % of the budget is spent on 10 % of patients.

It will not be reduced by an improvement in general health standards but will increase as society grows richer and can afford more and more of it [10, 11].

On the other hand, expenditure on routine care, even if not actually reducible, will at least remain more or less parallel to the population's state of health, on which physical exercise should have a considerable impact. The same applies to all the expenditure or reduced profit, still virtually unquantified, which partly results from physical unfitness (absenteeism, loss of productivity, accidents).

The cost of physical unfitness

The effect of sickness on the community's economic activity and income is a large uncharted field, statistics for which are still unprecise and hard to come by [12].

Not only is there the cost of treatment and allowances : there is a loss of production and possibly the waste of expenditure on education, which an individual only begins to pay back to society from the age of 40 onwards. The consequences of early interruption of occupational activity have been studied in relation to certain diseases. According to Åstrand [13], myocardial infarction caused Sweden an economic loss of 1,389 million crowns in 1964. A decrease of 10 % in the number of infarction cases would therefore have meant a saving of 139 million crowns. For France, it is estimated that 60 million working days are lost each year through road accidents, 80 million through unemployment and 280 million through absenteeism. Illness and industrial accidents cost France 40,000 million francs a year — almost 10 % of the GNP.

It must nevertheless be acknowledged that there is also a positive economic aspect to health expenditure. The Mushkin Report estimated that, in the United States, 13 million of the 67 million people at work were alive thanks to the decline in mortality rates since 1900 and were responsible for 10 % of the United States' economic growth during the last 50 years [14].

A new approach to the improvement of health standards

In the face of these new dangers and the inflation of health budgets, medicine has so far been using mainly the conventional — and necessary — weapons of therapeutic treatment, namely widespread use of psychotropic drugs for neuroses, intensive care for myocardial infarction cases etc.

Society has found it preferable to foot the heavy bill for medical attention for numerous disabled or retired persons, in need of treatment for conditions that are virtually irreversible once they have developed. It has been reluctant to pay for health education or for the prevention of those same diseases [6].

Another approach, a less passive one, is to try to bring about a radical transformation of urban environment and of the social climate. Such is the scale of the task that an early solution is unlikely ; this is a matter that depends not so much on medical techniques as on political and economic considerations.

But there will also need to be considerable changes in our personal way of life, our eating and drinking habits, our intake of intoxicants and our physical aptitudes [15]. Efforts must be made to improve the quality of man so as to complement, at last, the progress made in regard to quantity.

Medical progress is at the moment being cancelled out by the diseases of civilisation, which is giving rise to a new pathology. Medicine will eventually learn how to treat them, but it is not organised for preventing them. In the final analysis in preserving life it is merely prolonging the disease. Every endeavour should be employed to keep man healthy until his "biological death". Thus, the problems of public health are ceasing to be therapeutic ones and are becoming problems of detection and prevention, dependent on social, intellectual and also physical education.

A great effort of imagination is needed to gear prevention methods, which have been so successful in reducing infectious diseases, to the prevention of metabolic and psychosomatic diseases. This requires, amongst other things, an appraisal of the ill effects of a sedentary existence. What impact might physical and sporting activities have on public health, in both its medical and psychological senses ?

CHAPTER II

INFLUENCE OF SPORT AND PHYSICAL ACTIVITY ON PUBLIC HEALTH STANDARDS

When a disease becomes apparent, it simply reveals an often long history of undetected and untreated morbid factors, just as an iceberg shows only a small part of its total volume. This latent morbidity — the result of obesity, excessive smoking, inadequate respiratory capacity or mental instability in the face of stress, to mention only a few examples — may be prevented in varying degrees by the practice of sport and other physical activities. The relevance of such activites to cardiovascular diseases, neuro-psychological equilibrium, working capacity and the health of old people is discussed below, consideration also being given to the part they can play in promoting individual well-being and enjoyment of life.

Physical activity and cardiovascular diseases

The beneficial influence of sport on health, particularly on cardiovascular diseases, is generally acknowledged or at any rate sensed. Doctors have long been trying to place the idea on a precise statistical and physiological basis.

Table V summarises the findings of the main recent *demographic studies* on different sections of the population classified according to the amount of physical activity their occupations involve, and selected so as to be as homogeneous as possible.

The incidence of coronary diseases, myocardial infarction and mortality from coronary atheroma is compared as between persons with physically active occupations and persons with sedentary occupations. Where such diseases are less prevalent among active than amongst sedentary subjects, the active : sedentary incidence ratio will be less than 1, which would imply a protective effect by physical exercise with regard to those diseases.

Table V

Ratio of incidence of coronary diseases

$$\frac{\text{Incidence among active persons :}}{\text{Incidence among sedentary persons}}$$

Author - Year Place (reference)	Categories studied	Coronary diseases	Infarction	Deaths
Morris, 1953 London [16]	31,000 urban transport employees. Active conductors/sedentary drivers. 35-64 years	0.70	0.53	0.46
	180,000 man-years. Postal workers. Active delivery staff/telephonists and sedentary employees. 35-59 years	0.75		0.50
Brown, 1957 Birmingham [17]	1,062 men aged between 60 and 69, including 89 coronary sufferers			
	158 very active occupations/137 sedentary occupations	0.29	0.63	
	766 fairly active/137 sedentary occupations	0.53	0.60	
Chapman, 1957 Los Angeles [18]	772 civil service employees. 40-59 years 492 active/236 sedentary (differences not significant)	1.03	0.98	

(continued p. 16)

(continued from p. 15)

Author - Year Place (reference)	Categories studied	Coronary diseases	Infarction	Deaths
Zukel, 1958 N. Dakota [19]	1,886 controls and 288 cases of coronary diseases. Over 35 years of age. Farmers/ other occupations	0.70	0.48	
Stamler, 1954-57 Chicago [20]	740 public service employees. 50-59 years. Blue collar/white collar	0.78	Difference statistically not significant	
McDonough, 1964 Georgia [21]	3,102 agricultural workers. 15-74 years. Considerable/inconsiderable degree of physical activity	0.17-0.50		
Rose, 1969 London [22]	9,777 civil servants. 40-64 years. Ratio of incidence of ECG lesions. 3.561 walkers/436 non-walkers	0.61		
Brunner, 1949-59 Israel [23]	4,500 men (102 cases of infarction) 4,000 women (9 cases of infarction) 30-55 years. Active occupations/sedentary occupations. Same kind of life in 58 kibbutzim		0.33	0.33
Taylor, 1954-60 USA [24]	Railway workers Switchmen (61,630 man-years)/clerks (85,112 man-years) Section men (44,837 man-years)/clerks (sedentary employees fatter and more urbanised than manual workers)			0.63 0.49
Kahn, 1962 Washington [25]	1,664 postal employees. Carriers/clerks			0.53-0.70
Hammond, 1955-62 USA [26]	40-69 years highly active/inactive	Non smokers : Smokers :		0.57 0.70
Kannel, 1961 Framingham Study [27]	4,469 persons aged between 30 and 59, classified according to degree of activeness			0.28-0.47
Breslow, 1949-51 California [28]	45-64 years. Various occupations active/inactive			0.71
Franck, 1966 New York [29]	110,000 persons (Health Insurance Plan). 301 cases of infarction. 25-64 years. According to degree of occupational and/or non-occupational sports activeness			0.30-0.50
Tibblin, 1969 Göteborg [30]	973 men born in 1913 examined in 1963 and 1967 (23 cases of infarction). 267 highly active/302 sedentary. 263 average degree of activeness/302 sedentary		0.10 0.95	
Morris, 1968 Indiana [31]	10,520 farmers compared with 9,310 persons in sedentary occupations. 35-75 years	0.68		0.59
Sarvotham, 1968 India [32]	1,361 men and 661 women, aged over 30. Average degree of activeness/sedentariness	0.55		
Pfaffenbarger, 1951-1967 San Francisco [33]	3,263 longshoremen 291 deaths from infarction Highly active dockers/relatively inactive white-collar workers	35 to 44 years : 0.13 45 to 54 years : 0.64 55 to 64 years : 0.70		

At first sight the figures in the table clearly show the relationship between sedentariness and the incidence of coronary diseases. Although there are some studies which do not reveal this relationship (active : sedentary ratio close to 1 [18, 34, 35, 36]), there is none which confirms the contrary. Indeed, there are many studies not mentioned which point the same way, even though they do not give such precise figures. Furthermore, several authors have shown that in sedentary occupations infarction is not only more common, but also more fatal, and that it affects a lower age-group [18, 29, 31, 37, 38, 39].

The *longevity of athletes* has been studied to the same effect [40, 41]. In 1954, Rook compared 772 former Cambridge University athletes with 710 non-athletic controls who had studied at the same university between 1860 and 1900 [42]. The mortality rate among the former was not found to be statistically different from that among the controls, but it was not ascertained to what extent they had continued to lead a physically active life. To have been a keen sportsman at the age of 20 is no life-long guarantee, but the case is different if the habit of sporting activity is retained. In 1958, Pomeroy and White [43] studied the death rate among 355 former Harvard footballers (1901-30). 126 had died, 87 from known causes, including 25 from infarction. These had led a less active life than the others, and none of the 38 who had kept up sport had shown any signs of infarction during the 25-30 years since they had left university. In 1956, Karvonen [44] observed that the life expectancy of 318 Finnish skiers was seven years more than that of the population as a whole. There are, moreover, no general statistics which show that reasonable sporting activities, medically supervised and conducted outside competitions where record-breaking is the aim, have had a harmful influence on cardiovascular health.

All these coronary disease mortality and morbidity figures, although in broad agreement, should be *interpreted with caution*. It is always difficult, despite cross-checking of statistical analyses, to discover whether a worker was not prompted to take up a sedentary occupation or did not give up sport because he already had a coronary insufficiency. Amongst sedentary workers, mortality from cardiovascular diseases may be due not to their lack of physical activity but, say, to obesity, social class or stress. In physically strenuous occupations, mortality may be influenced by factors other than cardiovascular diseases, for example occupational hazards. The difficulty of identifying the cause or the effect is common to all these retrospective investigations [45, 46, 47].

With statistics of this kind there are a variety of factors which may produce a distorted picture, viz., a lack of precision in questionnaires, the uncertain dividing line between physically active and inactive occupations, the problem of changes of occupation, an uneven distribution between social, economic and intellectual classes, which do not necessarily coincide with the type of occupation, and selection as a result of conditions already existing. Above all, however, epidemiological studies of this kind only enable a very rough-and-ready distinction to be made between the direct role of inactivity and that of other risk factors (obesity, high blood pressure, hypercholesterolemia etc.), which are themselves in turn influenced by inactivity.

Prospective longitudinal studies on persons still free from cardiac injuries are more rigorous and conclusive here. Having eliminated doubtful cases, active subjects will be separated at the outset from sedentary subjects, and the incidence of coronary accidents will be compared in the two groups after some years' observation. Such studies are as yet insufficient in number and duration, but they do confirm the retrospective data [27, 30, 33, 48]. In this connection, it is interesting to study the effects of physical training on a number of persons selected at random, comparing them with controls not benefiting from such training. In this field sports medicine provides a wealth of interesting information.

Physically well trained people have a slower heart rate at rest and at each level of exercise, and their hearts show greater muscular development [35, 49, 50, 51, 52]. There is a greater output of oxygen at each contraction and improved efficiency on effort ; this enables the heart to economise between 10,000 and 30,000 beats in 24 hours [53]. These conditions will persist so long as training is kept up. The question is whether sedentary persons and middle-aged or elderly persons are capable of acquiring and maintaining the same conditions through physical training.

Investigations along these lines have been undertaken, especially in the Scandinavian and English-speaking countries and in Germany. A careful study has been made of such physiological

parameters as the acceleration of the heart and oxygen consumption during effort tests, as well as changes in cardiac volume and electrocardiographic recordings as a result of a period of training. These are the best criteria of adjustment to effort and of the efficiency of the heart's functioning. In Tennessee in 1969, Mann, for example, compared 62 persons representing all occupations, in apparently good health, aged between 25 and 60, before and after a six-month programme of training [54]. Their maximum oxygen consumption upon exertion rose from 34 to 40 ml/kg/min., which is still lower than that of young athletes (41-53 ml/kg/min.) but higher than that of the average sedentary population in the United States (35 ml/kg/min.). The increase in cardiac volume and the improvement in electrocardiographic changes are taken as proof of the development of heart muscle and the reversibility of senile involution.

In Illinois in 1964, Skinner [55] subjected 15 sedentary subjects aged between 35 and 55 to a six-month programme of progressive training consisting of 3-6 sessions of 30-45 minutes a week. By the end of the programme, in most of the tests used (step test, bicycle ergometer), the subjects were performing the same exercise faster, their heart acceleration was less, the rise in their blood pressure was lower, and they took less time to recover after their exertion.

In Stockholm and Göteborg in 1969, Kilbom and Saltin [56] studied 54 employees, aged between 35 and 50, whose physical activeness was slight. After a two-month programme of training, they noted an improvement in maximum oxygen consumption (from 37.5 to 44.3 ml/kg/min.), a reduction in tachycardia caused by exertion, an increase in maximum cardiac output and maximum breathing capacity (from 112 to 128 ml/min.) and, at rest, a decrease in abnormal ECG findings and a fall in diastolic blood pressure.

A few further remarks are called for on the basis of these studies and others which have given similar results. The improvements obtained in elderly people are, in almost all cases, comparable with those in young people ; old age is not, therefore, a reason for giving up regular physical activity. On the other hand, all these programmes had various minor ill-effects on the elderly subjects, especially in their joints and ligaments. Sporting activity should therefore be resumed only very gradually, after a thorough medical examination, and the type of activity should be carefully chosen. Perseverance is also essential ; this means a training schedule that is convenient and not too demanding.

In Cologne, Hollmann [50] compared the performances of 56 subjects in 1949 and 1964. In the 17 who had continued to have two regular sports sessions per week, maximum oxygen consumption had dropped by only 13 % (45 to 38 ml/kg/min. from 44 to 59 years). It had dropped by 38 % (42 to 26 ml/kg/min. from 41 to 56 years) in the 39 subjects who had given up sporting activities over those 25 years. In Göteborg, in 1968, Saltin [57] compared the adjustability to effort of 29 former athletes who had given up all sport 16-18 years earlier and who followed a sedentary occupation with that of their erstwhile colleagues who had achieved the same performances in their youth (cross-country running, long-distance skiing) but had kept up regular training. In the same age-group (50-59 years), maximum oxygen consumption was 30 ml/kg/min. among the non-athletes, 38 ml/kg/min. among the former athletes and 53 ml/kg/min. among the former athletes who had kept up sport. Generally speaking, the beneficial effects of sport on the functioning of the heart disappear fairly quickly once sport has been given up.

These discoveries concerning the physiology of work and sport are beginning to be applied in therapy [49, 50, 58, 59, 60]. The conventional prescription of complete rest for coronary subjects is no longer such an inviolable rule even after a myocardial infarction. Indeed, moderate and progressively increasing activity is now advocated in some cases to enable the vascularisation and trophicity of the heart muscle to recover more quickly. Such activity also has a psychological effect, and helps strengthen the patient's self-confidence, because he no longer feels that he is regarded as an invalid. The same ideas are being applied to the atheromatous pathology of cerebral vessels and arteritis of the lower limbs [61].

There is therefore a large body of evidence that physical exercise has a protective effect on cardiovascular health. The differences observed between sedentary and physically active occupations are more marked amongst highly active persons but are already appreciable amongst moderately active persons. It would seem that a beneficial effect can be obtained from three half-hour sessions

of training a week — a period which is compatible with occupational commitments — and that the effect can be maintained with even less training, provided it is done regularly. In terms of time, therefore, the cost of physical fitness is remarkably moderate.

It is not yet possible to assert, on the basis of long-term statistics, that physical activity will have much impact on the incidence of coronary disease, although it is not unreasonable to hope so. We can already state with certainty, however, that it helps considerably in reducing its seriousness.

By what mechanisms can the heart be thus protected ?

The increase in the incidence of coronary disease is known to be due to arterial atheroma occurring in the blood vessels and tending to obstruct them. There are two ways in which sport can help prevent such disease, namely directly, by improving the heart's vascularisation, and indirectly, by reducing the factors responsible for atheroma.

The direct effect of physical activity on heart muscle has been discerned in experiments [49], [50]. Autopsy reports show that atheroma of the blood vessels is less pronounced in physically active subjects. Spain and Bradess [62] analysed 652 reports of deaths from infarction, finding that subjects below the age of 55 accounted for 55 % of the 251 sedentary persons, compared with only 31 % of the 260 moderately active persons and 24 % of the 141 active persons. Out of 4,879 autopsies, Morris and Crawford [63] noted 3,800 cases of death from causes other than coronary disease. Myocardial fibrosis injuries were nevertheless twice as common in the subjects with sedentary occupations as in those who had been manual workers, and coronary vessel obstructions were observed in 5.8 % of the former compared with 3.2 % of the latter. These contrasts are not indicated in all autopsy statistics.

The heart is in fact also protected by a replacement circulation and adjustment to atherosclerosis which cannot be assessed by ordinary autopsies. Narrowing of the coronary vessels is less dangerous if a collateral replacement vascularisation and anastomoses between vessels have become considerably developed in the heart muscle. The need for oxygen is an effective stimulant of the development of this collateral circulation. Rose [64], using coronary artery injections, has shown that the increase in vessel calibre in physically active subjects provides them with better protection from infarction than is the case with physically inactive persons, and that the same plaque of atheroma is thus less of a threat to the heart. This has been confirmed by experiments on animals. Eckstein [65] constricted the coronary arteries of 90 dogs, one-half of which were subsequently subjected to six to eight weeks' training on a treadmill, so as to develop their collateral circulation. The increase in this replacement intra-cardiac circulation was greater in the dogs subjected to training, and in the case of slight strictures it was observed in those dogs only. Experiments on rats have given concurring results.

Ultimately, physical exercise cannot be relied on to prevent the formation of coronary atheroma ; it does, however, provide protection against the seriousness of the consequences of such atheroma, and enable the heart better to withstand its presence [27].

But even the best-trained heart is prone to infarction, the main cause being arteriosclerosis, the predisposing factors for which medicine has succeeded in identifying and quantifying. The risk of infarction can nowadays be evaluated almost mathematically — from the statistical standpoint of life insurance companies — by the detection of any such factors and by their summation. What are these factors and how far can sport reduce their effects ?

The coronary risk factors are hypercholesterolemia, obesity, diabetes, sedentariness, exposure to stress, high blood pressure, tabagism, heredity and clinically silent, electrocardiographic anomalies. These biological factors have been discovered with overwhelming frequency in the course of cardiovascular diseases. It is impossible to say whether they are the cause or the symptom, and investigations may well have revealed only associations and not real aetiologies. But these factors may be regarded as conducive. How significant are they and how can they be cured ? [27], [35], [36], [38], [48], [50], [66], [67], [68], [69].

The part played by *hypercholesterolemia* has been well established by numerous statistics (Framingham study [70, 71]). Persons whose cholesterolemia is higher than 2.30 g per thousand are in three times as much danger as others. Hyperlipemia (cholesterol, blood trigycerides) leads to a decrease in the coronary blood flow and a decline in myocardial oxygen extraction. It increases blood viscosity and encourages the tendency towards intravascular coagulation. It has been demonstrated that physical exercise reduces hyperlipemia produced by a fatty diet [72, 73], and fosters the action of lipolytic enzymes in the tissues. Numerous studies of different tribes or population groups have shown that the most active groups often — though not invariably — have the lowest cholesterol levels, despite a fatty diet. For instance, Samburu shepherds in Africa, who drink as much as six litres of milk a day (300 g of fat = 2,700 calories), have an average cholesterol level of 1.66 per thousand ; this is due to the highly active life of these nomad shepherds, whereas in sedentary town-dwellers, the same diet would produce much higher levels [74]. Observations among Eskimos and Somali shepherds have produced identical findings. Such studies must be treated with the usual caution, however, especially when comparisons are made between ethnic groups presenting genetic differences and seasonal feeding variations as well.

Is an increase in fat combustion through physical exercise able to bring down effectively the level of lipids in the blood ?

Experiments on animals appear to indicate decisively that it is [38, 75]. In the case of man, the findings of the most rigorous studies, conducted with reference to control values, are far from unanimous on this point [76]. The following table relates to studies in which no change of diet was imposed on the persons studied, only a change in their physical activity.

Table VI

Changes in cholesterolemia through physical exercise

I. Prospective studies

Author - Year Place (reference)	Population studied	Nature of physical activities practised	Cholesterol g per thousand		
			Before	After	Difference
Holloszy and Skinner 1964 Illinois [77]	15 sedentary men 35-55 years 12 men 32-77 years	6 months' intensive training 6 months' less intensive training (temporary reduction in cholesterolemia in those who lost weight)	2.44 2.33	2.54 2.33	N.S N.S
Montoye, 1959 USA [78]	15 middle-aged sedentary subjects	3 months' training	Initial level normal = no difference Initial level high = decrease		
Taylor, 1961 Minnesota [79]	5 groups of 5-9 subjects	3 weeks' walking training	Decrease in 2 of the 5 groups. Decrease influenced more by diet than by exercise		
Fitzgerald, 1965 Ireland [80]	LL subject aged 20-30	14 days' training (gymnastics)	2.24	2.20	N.S
Golding, 1961 USA [81]	A decrease in cholesterol was obtained only if weight also fell after exercise				
Mann, 1969 Tennessee [84]	62 men 25-60 years	After 6-month training programme	2.14	2.08	S.
Kilbom, 1969 Sweden [84]	42 sedentary men 34-50 years	After 6-month training programme	2.58	2.35	H.S.

II. Retrospective studies

			Sedentary	Active	Difference
Karvonen, 1958 Finland [82]	Population of East Finland 40-49 years	According to degree of occupational activity (but no difference before 40 years or after 50 years)	2.86	2.51	S.
	Population of West Finland		2.60	2.39	S.
Gsell, 1962 Switzerland [80]	Cholesterol level lower in mountain dwelling peasants than in controls living in Basle, despite fattier diet				
Kagan-Morris, 1960 London [45]	Bus drivers 607 sedentary persons compared with active conductors	40-49 years	2.49	2.28	
		50-59 years	2.54	2.38	
		60-64 years	2.62	2.46	
Hoffman, 1967 USA [84]	355 USAF officers 40-55 years	126 sedentary subjects compared with 299 in good physical training	2.24	2.13	S.
Grimby-Saltin, 1966 Sweden [57]	29 former sportsmen, compared with 33 who had continued to practice sport	43-49 years	2.31	2.22	
		50-59 years	2.77	2.51	
		60-67 years	2.66	2.86	
	Figures comparable to those for the whole population (Göteborg)				
Pyörälä, 1966 Helsinki [85]	Men 40-79 years	54 non-sporting controls compared with 61 long-distance skiers who had remained active	2.61	2.58	N.S.
Carlson, 1968 Stockholm [86]	Occupational physical activity : 773 inactive compared with 31 very active. Non-occupational activity : 378 inactive compared with 32 very active. Conclusion : the difference was due to populations studied and not to actual physical activity		2.72	2.75	N.S.
			2.77	2.45	H.S.
Rose, 1969 London [22]	8,948 civil servants 40-64 years	According to daily walking routine : 389 non-walkers compared with 3,301 walkers	2.04	2.04	
Pincherle, 1969 London [22]	6,946 subjects 25-64 years	Subjects classified by their doctors as non-active or active	2.58	2.54	H.S.

H.S. = Highly significant ; S = Significant ; N.S. = Not significant.

In practice, the stability of or slight decrease in cholesterolemia after prolonged exercise is difficult to analyse. The decrease in cholesterol can be connected with the decrease in the organism's reserve of fat, or with more or less conscious changes in diet, or with psychological factors (stress produces an increase in cholesterolemia). It seems that where weight remains constant and the increase of food intake is commensurate with the increase of activity, variations

in blood cholesterol remain slight. The only means of reducing cholesterolemia is to cut down the intake of food ; secondary variations due to actual physical exercise are too slight, in relation to the food factor, to be statistically meaningful. It is not that they are insignificant, but they are only clearly apparent if the individual is obese [87] or if his cholesterol level is high at the outset [78]. A very heavy diet produces a tendency to hypercholesterolemia when not accompanied by physical activity, but not otherwise [88].

It is more important, perhaps, to note the very significant decrease in triglycerides, a lipid fraction of serum involved in the pathogenesis of atherosclerosis. This decrease is particularly marked during the two days following physical exercise.

Repeated training sessions would therefore appear to be useful in reducing or stabilising the concentration of blood lipids and thus mitigating this risk factor [77, 84, 86].

Obesity has long been regarded by life insurance companies as an added risk. Among the cases examined and observed in the Framingham study, those whose weight was 30 % above normal were affected three times more than those whose weight was 10 % under that level, irrespective of high cholesterol or blood pressure figures, which are often associated with overweight. Death rates from numerous diseases (such as infarction), injuries and surgical operations are much higher in the case of obese people and vary according to the degree of obesity.

Obesity is no longer confined to a small social class with a high standard of living ; it is spreading throughout the population, now that everyone is able to indulge in the pleasures offered by the consumer society and gastronomic indulgence has become a common means of compensating for various frustrations.

For obesity to be reduced muscular expenditure of energy must exceed the intake of energising foods, any surplus of which is stored up in the form of fat. The primary need is, therefore, to reduce the intake of calories, but an increase in physical activity can make an important contribution [89, 90, 91, 92]. Sedentariness aggravates obesity, and obesity leads to a reduction in muscular activity [93, 94]. London bus drivers, whose occupation is sedentary, were found to be fatter (assuming equal height) and more subject to coronary deseases, than (more active) bus conductors [63]. A group of 17 sportsmen who had continued training between the ages of 44 and 59 put on 4.7 kg additional weight on average, each, over the space of 25 years, while 39 non-sportsmen, acting as controls, put on 9.1 kg between the ages of 41 and 56 years [59]. Physical exercise can clearly offset the effects of over-eating. 101 Marines who had a very rich diet (4,500 calories) for 22 weeks, and who at the same time underwent intense physical training, put on only 1.4 kg.[95]. A group of volunteers (prisoners) had a high calory and high lipid diet for 150 days, and remaining inactive steadily put on weight (+ 24.8 %). Their weight increase was halted when they took physical exercise, while continuing with the same diet [96]. Before any result is obtained, however, considerable exercise is needed : an additional two kilometres' walk every day for one year represents a consumption of 36,500 calories, or the equivalent of 6 kg of adipose tissue (P.O. Åstrand).

It is a curious fact that with groups of persons subjected to physical training and without diet restriction, who — as noted earlier — show cardiovascular improvement, there is virtually no difference between initial weight and final weight. The same fact was observed by Pascale in the case of US army paratroops undergoing strenuous training and by Pariskova in the cases of athletes who trained intensively for the sixteen weeks prior to the Olympic Games. Sports doctors are, however, mainly interested in the ratio of muscle to fat. They gauge this easily by measuring the density of the body and the thickness of the skinfold in various places. They all find that, while weight remains stable, physical exercise produces an increase in body density and a reduction in the thickness of skinfolds which signifies an increase in muscular mass to offset the decrease in fat [54, 55, 57, 77, 85, 97].

Table VII

	Weight kg	Density	Skinfolds Sum of 6 measurements
Skinner [55]			
Before training	79.65	1.058	107.7
After training	79.69	1.063	99.3
	N.S.	H.S.	H.S.
Novak [99]			
18 young sportsmen	67.30	1.083	8.3
20 non-sporting controls of the same age	66.70	1.065	13.0
	N.S.	H.S.	H.S.

Excessive slimming diets are not followed properly, and may produce qualitative malnutrition. It is better to eat more and expend more energy. Further, such diets eventually diminish reserves of muscular tissue as much as reserves of fat. It is accordingly important to maintain a certain level of physical activity for the preventive and remedial treatment of obesity and for the preservation of a proper balance between muscle and the necessary reserves of fat in a healthy individual's constitution.

The problem of obesity is akin to that of *diabetes*. Diabetes, which affects — latently or manifestly — at least one per cent of the population, causes a serious speeding up of the processes of arteriosclerosis. It may remain for a long time at the stage of unapparent hereditary predisposition, but there is much evidence to show that obesity is conducive to the development of diabetes and that, conversely, diabetes may disappear with a decrease in obesity. Although sport can do nothing about a congenital predisposition to diabetes, it can nevertheless reduce obesity which aggravates the predisposition [50, 85, 99, 100]. Again, among severe diabetes cases, treated with insulin, Larsson [101] has shown that with young diabetics aged 13-14 years, sports training had (besides cardio-respiratory effects) a beneficial influence on the stability of the disease.

Sedentary habits as we have seen, go hand in hand with a higher incidence of coronary disease. It is known precisely how far physical activity can improve the functioning of the heart and oxygen transport capacity. This direct action on heart muscle condition and vital capacity is supported by an indirect action on fat levels in the blood and on overweight.

This factor often occurs together with others, and it could seem to be merely associated with them in a secondary way. However, a comparison of percentages of mortality from infarction among active and sedentary subjects confirms that physical exercise provides protection. The comparison is frequently still favourable, even after elimination through statistical analyses of the part played by the other risks factors also present in the same individuals [22, 29, 30, 33, 38, 46].

In occupational activities, however, the tendency is for human physical effort to be gradually replaced by mechanical power, and the proportion of sedentary workers is rising ineluctably. Modern man, *homo sedentarius*, sits in his car, then at his desk and then in front of the television set. Sport will ultimately provide the only opportunity for the physical exercise which our biological and physiological system requires.

The role played by *stress* in general morbidity and the demand for treatment is particularly marked in the cardiovascular sphere [30, 102, 103, 104]. This role is difficult to quantify, as stress cannot be measured and it is often intertwined with other risk factors in our way of life. It is well known that people in certain occupations entailing severe strain (business, medicine, journalism) are

particularly prone to coronary conditions. Among lorry-drivers, it has been possible to show a connection between the risk of coronary disease and the number of kilometers covered in the course of a year.

The reaction to mental pressure brings about an increase in fat levels and viscosity of the blood and the release of catecholamines which speed up the heart rate. These reactions which are beneficial for animals and primitive people in the face of danger, may have very harmful effects, through repetition and because of their excessive scale, on a sedentary person's heart. They have been held responsible for myocardial fibrosis.

The emotional and somatic impact of a given kind of stress will vary widely according to the personality of the subject and according to his cardiovascular stability.

Jouve [105], studying 109 sufferers from coronary complaints in Marseille, observed a predominantly obsessional personality in 75 % of the cases, whereas the same personality was found in only 39 % of the 624 controls. The features of this personality are a state of chronic occupational tension, seldom relieved by holidays, ambitiousness necessitating strict personal discipline and excessive work, a feeling of insecurity, hidden behind a facade of composure, and hypersensitivity and susceptibility resulting in strong tachycardiac and vasomotor reactions to stress. This type of personality is not associated solely with coronary diseases, but it is one of the most common etiological factors.

The part played by stress in the formation of an infarct is difficult to define, but the detection of an obsessional personality should be taken into consideration in the prevention of coronary diseases. The influence of sport on the control of psychological and physiological reactions can contribute to such prevention, as will be seen, just as relaxation methods contribute to their cure.

Hypertension is another factor regarded as increasing the risk of coronary disease. It is now possible to control almost all cases of high blood pressure by appropriate dietary and medicinal treatment. It may be noted, however, that according to epidemiological surveys, hypertension occurs less often and later in life among the most active subjects [63, 85]. In the Miall survey [106] of 2,869 miners and farmworkers in Wales the difference ranged among persons aged between 50 and 80 years from — 17.3 mm/Hg of systolic pressure to — 10.1 mm/Hg of diastolic pressure, in favour of those with the most active jobs. Sports training programmes, generally speaking had a beneficial effect on blood pressure, particularly on the diastolic [49, 50, 56, 107]. Mann observed this clearly in his 62 sedentary subjects after six months' training, in comparison with controls. In Moscow Letounov [52] also observed it in elderly subjects and persons with high blood pressure (— 22 mm/Hg for systolic pressure, — 9 for diastolic). Hypertension resulting from exertion, still more significant than arterial pressure at rest was markedly lower among 80 trained subjects, aged 40-60, than among 50 controls not engaging in sport [154]. Lastly, hypertension may be caused or aggravated by stress, and here too sport can have indirect beneficial effects by facilitating adjustment to stress.

Tabagism has a clearly defined pathology, both broncho-pulmonary and cardiac [26, 66, 108, 109]. Suffice it to say that it is not unreasonable to think that sport leads to a reduction in smoking [156]. Pyöralä [85] finds this among Finnish former long-distance skiers (26 non-smokers and 7 heavy smokers out of 61), compared with non-sporting controls (13 non-smokers and 10 heavy smokers out of 54). Giving up smoking is essentially a problem of physical and mental determination, which sport is one of the best ways of developing. Sport may also provide a compensation for certain psychological motivations (evidence of virility, relief in a situation fraught with stress) which are the causes of smoking [110].

Nevertheless, it remains to be discovered whether smoking leads to higher incidence of coronary disease or whether people smoke because they have difficulty in adjusting to stress.

Inherited vascular characteristics cannot a priori be influenced by a person's degree of activeness, and so sport has nothing to offer the potential coronary subject in this respect. Heredity is not an insurmountable factor, however. A Swedish study concerning 91 pairs of twins aged between 42 and 67 years showed that frequently only one of the twins had a cardiovascular condition, and that

twins with infarction took less exercise during their free time than did their healthy brothers. Environment can therefore provide protection against a hereditary predisposition [111]. The discovery of such a risk factor is thus an additional incentive to reduce the others by all possible means, including sport. Besides, the congenital factor is often confused with living habits (sedentariness, over-eating) inculcated by family environment.

Electrocardiographic anomalies may sometimes be observed in isolation, without accompanying functional symptoms. They often reflect a latent coronary defect and their existence increases the risk of disease two-and-a-half times.

Here too, it has been possible to establish a correlation between living habits and the frequency of such anomalies. Thus Karvonen studied 815 Finns aged between 40 and 59 [112]. The most active were lumberjacks, numbering 380. They were found to have only one-quarter of the coronary electrocardiographic anomalies detected in the sedentary controls. Rose [22] studied the electrocardiograms of 9,777 London employees, aged between 40 and 64, in sedentary occupations, some of whom walked more than 20 minutes to work, the others less or not at all. In all groups lesions of the ischaemic type were to be observed, but with the following incidences :

Walking time	No. of cases	Percentage of ECG lesions
0 mins.	436	7.80
1-9 mins.	1,338	6.20
10-19 mins.	4,442	5.27
over 20 mins.	3,561	4.77

It therefore seems that physical activity has a protective influence as far as this coronary risk factor is concerned. Observations during physical training programmes confirm this view, since they show changes in electrocardiographic recordings signifying an improvement in cardiac functioning. Mann [64] observed this in a group of 62 persons subjected to six months' training, even among the oldest of them. Kilbom [66] observed electrocardiographic anomalies in 11 persons out of a group of 53 ; in nine cases there had been improvements by the end of the training programme.

These results are further evidence of the improvement which physical activity can bring about in the vascularisation of heart muscle.

***

The various coronary risk factors referred to above seldom occur in isolation. We have seen how they interlace and aggravate one another. In men aged between 40 and 59 the risks connected with atherosclerosis are doubled by the presence of one of these factors, quadrupled by the presence of two and increased twenty fold by the presence of four [30, 33, 46, 113, 114].

Today, medicine tries to indentify these "high" risk subjects but by that stage the harm has already been done and can rarely be undone. What is needed is to prevent such risk factors from occurring, and not to overlook any of the preventive measures. Physical exercise has a direct beneficial influence on the trophicity and efficiency of heart muscle. Hyperlipemia can be corrected by a diet balanced in respect of fats, obesity by a regulated calory intake, and the ill effects of stress by a change in living habits. But the combating of sedentariness is just as important since physical activity contributes to the reduction of hyperlipemia and obesity and incidentally to the lessening of hypertension and electrocardiographic abnormalities, and since sport can build up resistance to the physical and mental pressures of urban life [50, 53, 115, 116, 117, 118].

Arteriosclerosis is a multi-factor phenomenon, in which sedentariness is just one factor. Retrospective studies suggest, but do not prove, a definite relationship between the reduction of the incidence of coronary diseases and physical activity. Prospective studies have not yet provided any

categorical evidence, only a series of concurring arguments. It will always be difficult to work out the part played by physical exercise in statistical terms, because such exercise cannot be considered in isolation from other measures to promote healthy living, and because its effects are usually produced through a reduction in other disorders which are responsible for heart conditions. Once arteriosclerosis has taken root, exercise has little direct effect ; there is no doubt, however, of its effectiveness in combating the risk factors by which we are surrounded, and in the prevention of which a certain degree of physical activity or sport must participate. The effect of exercise is much more striking in terms of prevention than in terms of cure.

It has been said that coronary disease is a deficiency syndrome due to a deficiency of physical activity.

CHAPTER III

PHYSICAL ACTIVITY AND NEUROPSYCHOLOGICAL EQUILIBRIUM

Psychosomatic complaints — i.e. diseases, either functional or organic, whose starting point was inadequate mental adjustment to environment — are the subject of at least one third of medical consultations. These phenomena are usually described as the consequence of the stress of modern life.

Stress has been defined by Selye, the pioneer of this pathology, as a set of non-specific general phenomena caused by sudden exposure of the organism to various aggressive forces to which it has not adjusted either quantitatively or qualitatively. Stress means a mobilisation of the organism's defensive forces, which used to be necessary in primitive or animal life as a response to cold, lack of food etc. But the stress of modern life is different in nature and frequency. Its most harmful physical forms are overstrain, air pollution and tiredness from travelling, and assaults on the senses (e.g. illuminated advertisements or inadequate lighting, noise at work and noise at night, which can disturb a person's sleep even without waking him up).

As for mental and emotional stress, the hunting of bears in the struggle for life has been replaced by the hunting of qualifications and a "safe" job. Before the goal can be achieved, many mental and psychological ordeals have to be endured — financial worries, heavy responsibilities, boring tasks, family problems and many others. Furthermore, the increasing density of population is leading to an increase in aggressive behaviour, as witness motorists' driving habits.

The general reactions of stress are characterised by an activation of nerve centres and the adrenal glands accompanied by an increase in the secretion of catecholamines and adrenal cortical hormones [119]. This results in a rise in systolic and diastolic blood pressure, an accelerated heart rate, peripheral vasoconstriction and increased effort by the heart with excessive consumption of oxygen (wasting effect). Digestive secretions are also affected, as is the concentration of lipids and glucose in the blood. These reactions are combined with emotional phenomena and, if repeated, produce a state of "exhaustion". Brod [120] has well shown the intensity of such cardiovascular reactions in persons subjected to emotional stress, triggered off by a simple mental calculation operation, carried out at speed under control by a metronome. Reactions were even more marked among those with high pressure. Similar findings were arrived at following two hours' car driving : occurrence of tachycardia, electrocardiographic changes and increase in catecholamines secretion, all of which were greater in those with coronary conditions than in healthy subjects [121], [122].

The *impact* of such emotional tension and reactions *on public health* is accounted for by several factors which will need to be enumerated if we are to see how far it could be influenced by sport.

There first needs to be a predisposition. The somatisation of various discomfort is the only defence against anxiety fostered by the context of life. The rise in living standards and private incomes has considerably increased the demand for medical treatment of functional disorders which earlier generations had no opportunity to "cultivate". The spread of information is leading to mistrust in one's body and trust in drugs, whereas physical and intellectual education ought to lead to the reverse. Coupled with the predisposition, there is the summation of these various forms of stress, whose frequency and duration are intensified by urbanisation. From the physiological point of view, stress which produced "an emotion with a view to muscular action" is now but "emotion without action". The reactions set off by these mental strains exceed their purpose, become superfluous and ultimately cause lesions whose external manifestations are many and varied [119].

In the cardiovascular domain, "cardiac neurosis", with arrhythmia, palpitations and anginal pains, is due to a particularly high concentration of catecholamins secreted after emotion. There

are even electrocardiographic anomalies clearly influenced by the state of anxiety [102, 123]. Russian studies, for example, have established significant correlations between the unusual incidence of high blood pressure in young people and the emotional shocks caused by the siege of Leningrad.

There are many other systems in which these nerve-stretching reactions may manifest themselves, viz. gynaecological disorders, headaches, obesity and gastric disorders. In gastrostomy cases (opening of stomach through the skin) it has been possible to examine directly vasomotor changes in the gastric mucous membrane in response to given mental stimulations. Further evidence is the many spontaneous ulcerous perforations of the stomach which occurred during the bombing of London in 1940.

As far as "minor risks" (chronic fatigue, seasonal bronchial infections, colds, influenza) are concerned, there is no doubt that psychological factors influence the time the illness lasts and the date of return to work. Absenteeism is partly due to a desire to delay as long as possible the return to an occupational situation productive of anxiety.

Continuous emotional tension will no doubt continue to be the price paid by man for the material benefits of industrial society. From this he will seek an escape in alcohol and drugs and by alternately consuming tranquillisers and stimulants with their side effects. Nicotine, caffeine and amphetamines will enable the exhausted and depressed to keep up their efforts. There is little hope of psychosomatic morbidity being reduced by such methods.

Another method, perhaps too idealistic, is to try to adjust the individual's behaviour, discipline and physical resistance so that he is capable of tolerating mental stresses with a minimum of harmful reactions. This training should begin with childhood, the stage at which personality traits become fixed. Sport can play a fundamental role in this training and can sustain throughout adulthood the attitudes acquired.

Anyone claiming that sport makes an individual better able to withstand strain might well be accused of striking philosophical attitudes and displaying prejudices.

It is nevertheless acknowledged that people who are physically fit have added resistance to infection and fatigue and are free from any tendency towards psychasthenia.

Sport makes a person consider his body as a tool designed to function properly and usually be healthy. Such an attitude leads to a decrease in the somatisation of the anxiety-making stresses surrounding us, whereas a person who is physically unfit will tend to regard his body as usually being unhealthy. Confidence in one's body is the first line of defence against psychosomatic diseases. Moreover, the educational role of sport, provided it is not degraded by a competitive spirit or by nationalism, develops emotional stability and provides a wholesome outlet for normal aggressiveness.

In his study of the living habits of 396 veteran athletes, Longueville [158] observed that 90 % of those studied had not been off work at all during the year for health reasons and only 2 % had been off work for more than 15 days, whereas absenteeism in France averages 15 days a year per person. 48 % of those studied did not smoke and 24 % smoked less than five cigarettes a day. All doctors who have studied morbidity among sportsmen have found that it is often lower than the general average [85] and that elderly sportsmen succeed better in countering the inevitable wear and tear in their bodies both mentally and functionally.

The slower heart beat and better regulation of pressure in sportsmen mean that tachycardia and emotional vasomotor modifications can be better controlled. A striking example of this is provided by the treatment of "neuro-circulatory asthenia", a set of functional disorders, features of which include breathlessness after exertion, dizziness following change of position, palpitations, fatigue and anxiety, occurring against an habitual background of psychological traumatisms and mental justability : with sizeable groups of patients [50, 128], a six weeks' programme of graduated physical training had a direct effect on their subjective disorders, improving the peripheral distribution of the circulation, allaying anxiety and restoring a physical working capacity that had been

seriously impaired, although numerous drugs prescribed for the symptoms had failed. The persons in question, most of them young, had been kept as regular invalids, having in many cases been ordered to take a complete rest out of deference for a heart that was actually fit.

In the context of the group, the experiment of introducing sport in schools is particularly revealing [124], [125]. Compared with children who undergo the usual schooling in France, which comprises very little physical activity, those attending schools where mornings are devoted to classroom study and afternoons to sport and handicrafts show striking differences. They grow more quickly, their pulse is slower, and there is an improvement in their adjustment to effort and their motor co-ordinations. Their academic performance is better and they are less often absent from school. But above all, they are more inclined to observe the rules of communal life ; they are more energetic, balanced and open, and they achieve better integration in their family and educational surroundings.

The psychotherapeutic value of sport has been discovered in the treatment of certain psychiatric conditions. There is a progression from individual exercises to team games, with increasing respect for the rules of the game. The patient takes an active part in his own cure. Such methods cut down the consumption of drugs and reduce the period spent in hospital [127]. Yoga and autogenous training are used successfully in the treatment of headaches, insomnia and even cardiovascular functional disorders. These techniques are based on the analogies between muscular tension and psychological tension. The relaxation of muscular tension brings about an easing of mental tension and reduced susceptibility to various psychosomatic complaints.

Finally the *esprit de corps* and unselfishness engendered by sport effectively foster the socialisation of young people and children and eliminate isolation, a source of psychological conflict [128], [129], and reduce "apartment block pathology". With the increase in leisure time, the encouragement of physical activities will undoubtedly have a more beneficial effect on public health than the encouragement of purely audio-visual, passive and sedentary pastimes.

CHAPTER IV

PHYSICAL ACTIVITY
LOCOMOTOR SYSTEM AND CAPACITY FOR WORK

Health depends not only on the cardiovascular state and neuropsychological equilibrium, but also on the proper functioning of the locomotor system. Works physicians come more and more frequently across cases of articular pains, spinal pains and lumbar contractures. These complaints have a long history (the spinal columns of Egyptian mummies show the same signs of degeneration as are to be found in people today). Only, they now seem to be more frequent, as they are no longer suffered in silence, and the widespread use of bone radiography has revealed degenerative osteoarticular lesions which may be placed under the general heading of arthroses.

These arthroses of the main joints and the spine are the result of poor working postures, in active and sedentary occupations alike. The backbone, with its 75 articular surfaces is especially exposed to premature degeneration since it takes part in all static and dynamic efforts and is never at rest. An uneven distribution of effort, as in the case of excessive periods of immobility, accelerates both the normal and premature process of ageing of the joints. On the other hand, well-developed and well-balanced muscular masses protect the spinal column, prevent over-straining of the joints and lead to better tolerance of incipient arthrosis. Muscular contraction and movement in general play an essential part in the proper trophicity of bones and cartilage tissue.

The studies reported by Åstrand [115, 130, 131] demonstrate clearly the ill effects of prolonged immobility. Student volunteers were kept in bed for 3 - 6 weeks. By the end of that period, there had been a marked decrease in their muscular mass and of skeletal calcium content as well as in their cardiovascular capacities on exertion. The most spectacular example is that of the cosmonauts, in whom enforced immobility caused approximately a 10 % loss of bone calcium.

A muscle pattern completely at rest will lose up to 3 % of its strength per inactive day, as the result of muscular atrophy and loss of elasticity in the connective tissue [132].

The most common complaint brought to the attention of doctors is fatigue. It is not only the result of weakening of the muscles and stiff joints. It is also mental, produced by the strain of observation, sustained attention and the monotonous rhythms of a great many present-day jobs.

Fatigue can be reduced by sports training, which boosts general physical resistance and makes it possible to tolerate or correct the consequences of sedentary habits, the immobility of the body or the bad posture imposed by the occupation. Working hours and shifts being what they are, efforts have been made to overcome their ill effects by the introduction of breaks for physical exercise, during work, the form of exercise being selected in the light of the postures and movements peculiar to each activity. The theory behind this "active rest" is that a muscle pattern that is tired from repeated exertion is better rested through the exercise of other muscle patterns than through merely stopping that particular exertion (passive break). These experiments, which are being carried out in many countries, have given surprising results [133, 134, 135, 136].

Mention may be made, for instance of the study carried out at the Postal Cheque Centre in Brussels [137]. A comparison was made between two groups of 40 young women, one of which performed simple gymnastic movements during the break, while the other, the control group, did nothing. From tests made before and after the break, it was found that the active group showed a decrease in general fatigue and eye-strain and an increase in muscular strength. Some mental relaxation was observed, as well as an improvement in efficiency, with a 31 % reduction in the number of errors in a five-month study of female textile workers. Martchouk showed that the introduction of physical education sessions during work reduced the number of days' absence from 426 to 292. For 100 persons, absenteeism due to influenza fell from 100 days to 47 and the number of reported cases from 29 to 13.

The many reports on the effects of a gymnastic break all show a decrease in morbidity and absenteeism, psychological improvement and an increase in output and accuracy. Given too a decrease in the number of accidents at work, it is understandable why some employers introduce these 5 or 15 minutes of gymnastics during working hours.

Industrial safety benefits considerably from the improvement in physical capacity, which perhaps exerts its greatest economic effects in this field, since apart from the direct cost involved when a worker is injured and has to stop work, there are considerable indirect costs (decreased productivity, deterioration of equipment, surgical treatment, disablement pensions). Accidents are usually the result of a combination of many factors, but in two thirds of all cases, the main cause is a human failure. Accidents frequently occur in handling operations which are not carried out properly because of poor physical condition. Without wishing to turn all workers into specialists with the dumb-bells, we can be sure that lack of strength and agility, poor balance and sluggish reactions are largely accounted for by lack of sport. La Fay [138] studying coal mines in northern France has calculated the number of absences caused by sickness and injury among 360 sportsmen (between the ages of 17 and 32) and 1,442 non-sportsmen of the same ages. Among underground workers, absenteeism was 5.50 days in the case of sportsmen and 10.08 in the case of non-sportsmen. Among surface hands, absenteeism was 2.67 in the case of sportsmen, compared with 6.54 in the case of the reference group ; the ratios were much the same when sickness and industrial accidents were taken separately. An enquiry by a public works firm in Saint-Étienne (France) revealed 5.1 days' absence among employees who practised sport compared with 28.6 among the others of the same age and with the same length of service.

These examples are not isolated. They provide confirmation in the field of industrial pathology of the importance of good physical condition, which in this day and age can be acquired and sustained only through sport. A form of physical education geared to the risks attached to a specific job is essential in training programmes for young people. Some vocational schools in France *(SNCF, Gaz de France)* have fully appreciated this problem and a large part of the trainees' time-table is devoted to various sports and physical activities chosen in relation to their occupational specialisation [139, 140, 141, 142].

The same observations are applicable in the case of traffic accidents. Although excessive self-confidence may sometimes lead a person to take unnecessary, dangerous risks, sport can at the same time enable a person to judge accurately his own capabilities and improve his reflexes.

To sum up, sporting activities develop physical aptitudes (agility, stamina, resistance to obesity, better balance), mental aptitudes (reactions to environment, emotional control) and social aptitudes (sense of responsibility, *esprit de corps*) [143].

A full study of these benefits has been made among small occupational groups, but as far as wider sections of the population are concerned the economic cost of physical unfitness is still a subject about which little is known, except in relation to traffic accidents. If the figures advanced were reduced by only 10 % — to take the most pessimistic view — through the expansion of sport education, the saving would soon offset the cost of facilities needed for that expansion.

CHAPTER V

PHYSICAL ACTIVITY AND AGEING

The number of old people in Europe is expected to rise considerably both in absolute and relative terms. We are not now talking about very old people, whose expectation of life is scarcely increasing any further [7], and for whom sustained physical activity for preventive purposes will not have any effect on longevity and is no longer indicated. But much can be done in the ever-lengthening period between retirement and actual senility to raise the "quality" of the ageing process and the health of the elderly, which is particularly vulnerable in both physical and mental terms. The aim should be to "add life to the years, rather than years to life" and to make old age agreeable, or even useful, by trying to contain its morbidity.

The *physiological characteristics of ageing* indicate what problems need to be solved [144, 145, 146, 147, 148, 149].

A senescent mind is influenced by the decline in certain intellectual aptitudes, leading to rejection by a society in which occupational adaptability and re-training are increasingly essential. As an old person's sensory powers, such as sight and hearing decline, as his energy and psychomotor efficiency become impaired, and as he becomes increasingly dependent on those around him, he loses confidence in his body and, as a result, may suffer from general anxiety and depressive tendencies. The sudden and unprepared transition from working life to retirement, the feeling of uselessness and the drop in the level of social activity all contribute to old people's psychological isolation.

Physically, senescence is characterised by respiratory insufficiency due to poor skeletal postures, a reduction in ventilation and to emphysema, aggravated by air pollution and bronchial infections. In the locomotor system, senescence of the joints, bones and muscles is rapidly decompensated by the progressive decline in voluntary activity. Enforced inactivity makes an old person bed-ridden. Cardiovascular senescence is connected with arteriosclerosis, and most of the factors conducive to the latter continue to operate. The decline in the functions involved sets in round about the age of thirty and continues slowly and steadily [144, 150].

Diseases of wear and tear, such as bone and articular pains, functional impotence, poor respiration and mental disorders, bring with them greater vulnerability to infection. Surveys indicate that 80 % of persons over the age of 60 no longer feel in good health. Their intake of medicines is restricted only by their indifference and the slenderness of their resources.

The therapy for these conditions involves numerous forms of organo-therapeutic, vitamin, neuro-psychological and hormone treatment. Their curative effect is slight, their preventive effect virtually nil, and their cost considerable. There is no question of halting the inevitable physiological ageing process of the arteries, respiratory system and joints ; it is possible however, to slow down their decompensation and to transform them into latent conditions.

It is accordingly essential to continue to follow the rules of healthy living described above in order to combat the pathology of civilisation in adulthood. The place of physical activity in such prevention is significant [151, 152, 153].

Physical exercise is feasible for old people provided it is graduated, adapted to their condition, controlled medically and free from any spirit of competition [148, 149, 153, 154, 155]. A sudden resumption of sports training after a break of 20 or 30 years may be disastrous for a 60 year-old. Where there has been no break, the same exercise will be beneficial. It should not take the form of athletic activities that are associated with playing fields or gymnasia but should consist of moderate individual or group activities, such as walking, gardening, cycling or bowls. If the exercise is to be beneficial, however, some energy must be expended. Such physical activities should be supplemented by breathing and loosening-up exercises.

Tests on elderly people who have kept up sport have all shown a marked superiority as regards performance, cardiovascular functioning and stamina in comparison with sedentary controls of the same age. A sharp distinction may be noted between those in training and those not in training up to beyond the age of 70.

Table VIII

Principal findings relating to physical training among elderly persons

Author - Year Place - Reference	Population studied and type of training	Effects of training
Barry, 1966 Philadelphia [158]	8 persons between 55 and 78 years, compared with 5 controls between 58 and 83 years, studied before and after three months' training (three 40 minutes' bicycle ergometer sessions per week).	— 78 % increase in maximum work done, with 50 % increase in pulmonary ventilation (35 to 53 l/min) and 38 % increase in maximal oxygen intake on exertion. — Decline in tachycardia (126 to 106 min.) and blood pressure (190 to 170 mm Hg) following exertion. — Improved results of psychological tests.
Bernestad, 1965 Oslo [180]	13 men aged betwen 70 and 81, studied before and after 6 weeks with three weekly treadmill sessions.	— Decline in tachycardia on exertion from 131 to 117/min. — Improved heart work efficiency. — Decline in cholesterol level (2.70 to 2.57 g. per ml.). — Feeling of improved well-being expressed spontaneously.
Fischer, 1965 Prague [180]	84 men aged between 60 and 69 34 men aged between 70 and 79, one-half of whom trained on bicycle ergometer.	— Increased maximal oxygen consumption on exertion (+ 15 %) and maximum breathing capacity (+ 22 %). — Trained subjects equalled the performances of untrained subjects 10 years younger.
Drews, 1966 Münster Bochum [154]	50 men between 40 and 60, not in training, compared with 40 engaging in sport for one or two hours per week, and 40 regular sportsmen.	— Exertion tests showed an improvement in heart work efficiency, oxygen pulse and blood pressure, commensurate with the degree of training.
Saltin, Grimby, 1968 Sweden [87]	Subjects between 50 and 67 5 leading sedentary lives compared with 4 engaging in sport (skiing, cross-country running).	— Increase in maximum oxygen consumption (37 and 43 ml/kg/min.) and less heart acceleration (170 and 165/min.) on exertion.
Hollmann, 1970 Cologne [148, 149]	133 subjects between 50 and 70 one-half of whom have engaged in various sports for at least 2 hours per week, without interruption.	— Improvement in breathing capacity tests on exertion, increase in maximum oxygen consumption, (25 %) and in capacity to deliver oxygen to tissues. Cholesterol level lower (50-60). Increased capacity for exertion. Performances comparable with those of untrained controls between 20 and 40 years younger.

Numerous writers [146, 153, 157] note in addition to these cardio-respiratory improvements, relatively simple to express statistically, a beneficial effect produced by physical activity on sleep, appetite and malnutrition or overweight, muscular strength and flexibility of joints, and on powers of intellectual concentration.

These physical activities call for such organised facilities as specialised clubs for old people (Hilversum [146]) workshops for elderly workers, physiotherapy centres. The same needs are met if retired persons continue to work on a part-time basis ("factories for old people" in Belgium, "Employment Fellowship" in Great Britain [153]). The virtue of such activities is that they provide an interest centre and counteract passiveness. When carried on in a group, they combat isolation, compensate for family disintegration and widow(er)hood and prevent old people from being segregated. The few experiments that have been carried out are most encouraging, but need to be vastly expanded.

To sum up, physical activity produces a marked improvement in old people's wellbeing and delays the functional ageing process. It does not slow down the anatomical evolution of lesions, but it does bring about a functional adjustment which offsets them and makes them tolerable over a long period. It provides a psychological stimulus to resist the ageing process and enables morbidity to be reduced, and with it consumption of drugs [146, 152, 153, 156, 157].

Physical exercise for old people should not, however, be regarded as a miraculous means of rejuvenation. Further measures are needed : attention to diet, dental treatment, correction of defective hearing, not to mention social and economic measures. Exercise does, however, help people to "live out their old age as well as possible" [157]. A special effort should be made to sustain in adulthood the enjoyment of movement which is natural in children, so that it continues into retirement. A public which tends to think in terms of having a "well-earned rest", at an age when living habits make it possible to forego physical exercise — just when it is even more important — should be made to realise, through health education, the value of such exercise. Our way of life, the reflection of a society geared to sport, should enable the senility stage of ageing to be delayed as long as possible.

CHAPTER VI

PHYSICAL ACTIVITY AND ENJOYMENT OF LIFE

It would be wrong to see the development of physical activities solely from the utilitarian angle of labour productivity and the cost of sickness. It is a facet of the quality of living, a form of welfare which society has a duty to make available to the members of that society for their own sake. The definitions and conceptions of the good life are legion. We will do no more than recall certain of its essential conditions : physical stamina, mental equilibrium, social integration. It is more difficult to acquire these advantages than merely to stave off sickness. From Aristotle and Plato onwards, philosophers have pondered deeply on the methods and aims of physical education, and on the way in which a good physical condition impinges on the mental state [161], [162], [163].

It is not always possible for experimental studies to yield conclusive evidence. The various personality factors cannot be readily quantified. Tests have been carried out on numerous groups of students or patients, and control groups, before and after training [164]. 270 West Point cadets, former high school "lettermen", were found to be more sociable, enthusiastic, "adventurous", venturesome and integrated within their group than were their controls [165]. Other studies, however, making use of different psychological tests, did not reveal any contrasts between sportsmen and non-sportsmen. Experiments with the introduction of sport in schools are eye-opening because of psychological and social results, and also because of their physical and intellectual effectiveness [126]. The experience of psychiatric hospitals using sport rehabilitation methods indicates substantial headway when it comes to patients' social reintegration [127].

For the individual, sport improves his self-control and assessment of his potentialities. It creates an awareness of the relation between effort and progress. It stimulates the desire to improve and to combat backsliding. It makes it easier to adjust to the rapid changes of present-day life by reconciling physical capacities and mental stability. It can contribute substantially to the control of drug and alcohol addiction [166].

Considerable attention has already been paid to the part played by sport in social integration. Respect for the rules of the game helps form character, imparts an understanding of discipline, provides a preparation for accepting, and enjoying responsibility, and facilitates integration within an increasingly compulsive communal urban form of life. Sport provides an opportunity for people to remain in contact with nature and to occupy their leisure with freely chosen pursuits — not at all the same thing as idleness [167], [168].

The physical and mental satisfaction offered by sport is an integral part of the new way of life which is the aspiration of the inhabitants of industrialised countries, where spare time and living standards are steadily increasing.

CONCLUSION

Physical exercise and sport play an important part in the prevention of cardiovascular disease, excess fat and wear and tear on the locomotor system. Besides sedentary habits, there are many risk factors for such conditions, but physical activity is always a means, in some degree or other, of remedying them. Physical activity should be regarded as a biological need which our present way of life can no longer satisfy spontaneously.

The communal benefits of sport need to be considered with reference to social relations and industrial productivity. It is not yet possible to say how far the practice of sport can reduce the cost of sickness in terms of both medical expenditure and reduced productivity, since the exact causes of such expenditure have still not been adequately analysed and quantified. Nevertheless, considering the fairly low cost of certain sports facilities on the one hand and the increase in medical and socio-medical expenditure on the other, investment in sport can safely be said to be financially profitable.

Physical activities are beneficial for health provided they are pursued from childhood to old age, in forms suited to a person's age and capacities, under medical or paramedical supervision, if possible. Moderation and regularity are the best guarantees of efficiency. On the other hand, intensive training for competitive purposes and a sudden resumption of physical activity after a lengthy interruption entail specific risks. It is probably too late to make up for lost time in the case of a great many adults ; physical education will only be effective with the population at large provided it is undertaken before the age of thirty.

It is often difficult to say for certain that good health in particular individuals or communities is due to their activeness or practice of sport, even though the two things usually go together. Possibly, it is a mental attitude and health training at the outset that both inculcate in a person a liking for sport and lead him to observe other principles for healthy living. While the benefits of sport are significant for their direct preventive effect on predispositions to disease and on risk factors, they are possibly still more so by virtue of the development of this psychological attitude towards health. A sportsman will have confidence in his body and keep it in the best possible form so that it can carry out his decisions. This in turn will condition the whole of his behaviour vis-à-vis food, hygiene, smoking, alcohol, resistance to stress etc. An inactive person, on the other hand, will be inhibited by his lack of fitness and will submit to what he believes to be his body's decisions. Physical education, in the case of young people, and participation in sporting activities in the case of adults, are necessary to induce and sustain the kind of behaviour that can preserve health from the onslaughts of present-day living.

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